BROOKHAVEN NATIONAL LABORATORY

PETITION TO SHUT-DOWN
OU III Carbon Tetrachloride Groundwater Treatment System

April 2004

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this formal petition to shut-down the Operable Unit (OU) III Carbon Tetrachloride System is to document that the present conditions of the groundwater meet the objectives for shut-down as outlined in the Action Memorandum (Final Action Memorandum Carbon Tetrachloride Tank Groundwater Removal Action, BNL, January 1999) and that this shutdown is consistent with the criteria established in the OU III Record of Decision (ROD) (BNL, June 2000).

1.2 Regulatory History

BNL is a federal facility owned by the United States Department of Energy (DOE) and operated by Brookhaven Science Associates (BSA). On December 21, 1989, the BNL site was included on the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) National Priorities List (NPL) under Section 120 of CERCLA. The United States Environmental Protection Agency (EPA), New York State Department of Conservation (NYSDEC), and DOE entered into a Federal Facilities Agreement, which became effective in May 1992, herein referred to as the Interagency Agreement (IAG) Administrative Docket Number: II-CERCLA-FFA-00201. The primary concern addressed in the IAG is the protection of the sole source aquifer for Suffolk County which underlies OU III. This was documented in the OU III ROD which stipulated that the cleanup of the groundwater in the Upper Glacial Aquifer at BNL meet drinking water standards or Maximum Contaminant Levels (MCLs) in 30 years or less.

1.3 Site Description and Release History

As part of the Facility Review process conducted by BNL in 1997, a 1,000 gallon underground storage tank (UST) that had been used for an experiment at the former Chemistry Department complex in the 1950s was identified and located (southwest corner of Rowland Street and Rochester Street). The tank was pumped of its contents in the 1950s. This UST was one of the 14 significant findings discussed in the Interim Report of the BNL Facility Review; *Priority Two Facilities*, dated 12/3/97.

Carbon tetrachloride was discovered in the groundwater following removal of this tank on the BNL site. The tank was located at the southwest intersection of Rowland and Rochester Streets on the BNL site (Figure 1). The tank was removed on April 10, 1998 following a night of heavy rains (over 2 inches), which filled the hole with several feet of water. A storm drain line and monitoring well (85-06) were also removed during the excavation process. The storm drain line was replaced following removal of the tank. Upon removal, it was observed that the tank contained about 15 inches of water, which is about one-third the tank's height. It is unclear whether the tank accumulated the water from the preceding day's rains or whether the tank collected water over time while buried. A "dime size" hole on the side of the tank was the likely cause of water intrusion and liquid discharge. Two soil samples from below the tank were taken as well as one sample of the liquid from inside the tank after removal. The tank was buried to a depth of 20 feet below grade. This made inspection difficult until after removal. The soil samples under the east and west sides of the tank contained carbon tetrachloride at 7 parts per billion and

non-detect, respectively. This concentration is well below the New York State clean-up objective of 600 ppb. The liquid sample from the tank resulted in concentrations of carbon tetrachloride of 560,000 ppb. This liquid was pumped out of the tank into drums for off-site disposal. On April 21, 1998, Suffolk County Department of Health Services (SCDHS) provided a letter to BNL stating that they had no objection to backfilling the hole.

Prior to the detection of high levels of carbon tetrachloride in monitoring well 85-98 (up to 179,000 ppb), lower levels of this contaminant were routinely observed in nearby former well 85-06. Well 85-06 was installed in 1993 as part of the ERD Sitewide Hydrogeologic Characterization Project conducted under the DOE/EPA/NYSDEC IAG.

Well 85-06 had a ten foot screen that was located close to the water table. At that time a second well, well 85-07, was installed in the basal section of the Upper Glacial Aquifer. The following year, 1994, well 85-13 was installed in the uppermost portion of the Magothy Aquifer. These wells were designed to evaluate vertical hydraulic gradients in the central area of the BNL site. Information regarding the existence of the former carbon tetrachloride tank was not available prior to the installation of the wells.

Wells 85-06 and 85-07 were initially monitored in 1994 to evaluate groundwater quality in the central section of the BNL site. The wells were then monitored as part of the OU III RI/FS in 1995, and were monitored quarterly since 1997 as part of the OU III groundwater monitoring program. Low-level carbon tetrachloride and chloroform have been routinely detected in well 85-06 since 1995. The maximum observed concentration of carbon tetrachloride was 18 ppb in 1996, whereas the maximum concentration for chloroform was 3 ppb. Carbon tetrachloride has not been observed in either well 85-07 or 85-13. It should be noted that other VOCs such as TCA, DCA, and DCE have been routinely detected in well 85-07. However, these contaminants originate from up-gradient sources unrelated to the operations of the former carbon tetrachloride tank.

Since monitoring well 85-06 had been removed during the tank excavation, BNL, with concurrence from SCDHS, installed a new shallow well on May 22, 1998. This well, 85-98, was screened at the water table (50 ft deep with a 15 foot screen) and installed directly downgradient from the former tank location and just south of the former well. Well 85-98 was sampled for the first time on 6/19/98 and again on 7/30/98. The results from the 6/19 sample and 7/30 sample showed 99,500 ppb and 24,000 ppb of carbon tetrachloride, respectively. Results as high as 179,000 ppb were detected in this well. The drinking water standard for carbon tetrachloride is 5 ppb.

In response to this a groundwater investigation was initiated in this area to determine the extent of this contamination. This investigation determined that the high concentrations of carbon tetrachloride in groundwater were confined to the location of the former tank. In response to these results an Action Memorandum (Carbon Tetrachloride Tank Groundwater Removal Action, BNL, January 1999) was written, which documented plans to perform a time critical groundwater removal action at this location. This action, which was performed in January 1999, involved the construction of a temporary groundwater pump and treat system utilizing monitoring well 085-98 as a pumping well. Although this action was successful at removing a

significant portion of this contamination from the groundwater, the results indicated follow up actions were required.

A pump and treat system, consisting of two groundwater extraction wells and liquid phase granular activated carbon (GAC), was installed in June 1999 and started up in October 1999. The system was installed as a source control measure to contain and treat the high CCl_4 concentrations in the source area near the former UST. Routine groundwater compliance monitoring results indicated that a portion of the CCl_4 plume had migrated beyond the influence of the extraction wells warranting further action. Additional characterization was performed early in 2001 to better define the down gradient extent of the CCl_4 plume in these areas and the data was utilized to install an additional extraction well (EW-15). This well began operations in December 2001 and has been successful in addressing high concentrations of CCl_4 identified in down gradient areas.

During 2002 two additional vertical profiles were installed to determine the depth of contamination immediately upgradient of the former source and near well 95-88 where deeper carbon tetrachloride has been detected. Significant deeper contamination was not detected at either location in these profiles. A summary report detailing the information was provided to the regulators in October 2003.

2.0 SYSTEM SHUT-DOWN CRITERIA

2.1 System Shutdown Determination

As discussed in the Carbon Tetrachloride Operable Unit III *Final Action Memorandum Carbon Tetrachloride Tank Groundwater Removal Action (BNL, January 1999);* this project was initiated as a removal action for groundwater. The objective of this removal action "was to remove as much of the high concentrations of carbon tetrachloride in the groundwater as possible before it migrates away from this area". This removal action was documented as the final action in the OU III ROD.

The performance goal for VOCs in groundwater as stated in the OU III ROD is to meet MCLs in the Upper Glacial Aquifer in thirty years or less and to prevent or minimize plume growth. The OU III ROD further states that "*The exact number of years of active groundwater treatment needed to achieve Remedial Action Objectives will be determined based upon monitoring and operating data. If, after source control is complete and effective, monitoring indicates that continued operation of the selected remedy is not producing further reductions in the concentrations of contaminants in groundwater, in accordance with the National Contingency Plan, DOE, NYSDEC and EPA will evaluate whether discontinuance of the remedy is warranted. The criteria for discontinuation will include but not be limited to complete and effective source control, an evaluation of the operating conditions and parameters and a determination that the remedy has attained the feasible limits of contaminant reduction and that further reductions would be impractical. This performance goal is consistent with the decisions of the ROD and is protective of human health and the environment."*

This Petition will demonstrate that shutting down this treatment system is consistent with the goals established in the Action Memorandum and the OU III ROD.

2.2 Groundwater Remediation System Operational Summary

2.2.1 System Description

The Carbon Tetrachloride Pump & Treat System, consisting of three groundwater-extraction wells, is located in a building (TR-829) at the southwest corner of Rowland Street and Rochester Street. The first well, EW-13, is sited in the source area, adjacent to the building. The second well, EW-14, is further south, on the west side of Rochester Street. In December 2001 a new extraction well (EW-15) was added to the system. EW-15 is located 1,100 feet east south east of the treatment building **(Figure 1**). This well was located to capture the high concentration portion of the plume, which had migrated downgradient of the two existing wells. Each well consists of a submersible pump sending water to three 2,500-pound granular activated carbon filter vessels housed in the treatment shed. Treated groundwater returns to the on-site drainage system via a 4-inch PVC pipe to a catch basin on Rowland Street. A SPDES Equivalency permit was obtained from the NYSDEC for this discharge.

The treatment system is designed to operate at rates up to 70 gpm. Operational monitoring data suggests that actual rates vary during the life of the system. Each well is 6-inches in diameter with a 20- foot long, 20- slot, 304 stainless-steel screen. **Table 2.2.1** shows the extraction well and pumps settings.

Table 2.2.1 Carbon Tetrachloride Extraction Well Construction Data

Well	Screen Interval (Feet below grade)	Pump Setting (Feet below grade)
(EW-13, 085-158)	32-52	42
(EW-14, 085-159)	32-52	42
(EW-15, 095-278)	65-85	75

The groundwater treatment facility consist of the treatment shed set on a concrete slab housing three 2,500-pound granular activated carbon absorber vessels in series, PVC piping, valves and gauges, including starter and electrical panels, lighting, and space heating.

To evaluate the performance of the system, six sample ports are located in the treatment building. Four locations evaluate the performance of the carbon units, taking samples at the influent point, midpoint 1, midpoint 2, and at the effluent. Three additional sampling points are located on the influent piping from the extraction wells.

The water is discharged via a 4-inch PVC pipe from the treatment building to a nearby catch basin near the intersection of Rochester and Rowland Streets. The catch basin is piped to an open drainage channel near the supply and material area that drains to a storm water recharge basin. **Figure 1** shows the piping route.

2.2.2 Groundwater Monitoring

Well Network: A network of 32 wells was designed to monitor the extent of the plume and the effectiveness of remediation (**Table 1**). The BNL Groundwater Model was used to site the wells. The network was organized into plume core, perimeter, Bypass Detection and bypass/Middle Road Tracking wells as part of the DQO process; well designations/locations are shown in **Figure 2.** The wells are designated as follows:

- Plume Core – utilized to monitor the high concentration or core area of the plume. In addition, plume core wells will be used to provide data for measuring the performance of the source control measure.

- Perimeter – used to monitor the horizontal and vertical boundaries of the plume.

- Bypass (Middle Road Tracking) – used to determine whether the contamination already downgradient of the groundwater remediation system will be captured by the Middle Road system.

Sampling Frequency and Analysis: The wells are sampled quarterly, and samples are analyzed for VOCs via EPA Method 524.

2.2.3 Monitoring Well Data Plume Description

Carbon tetrachloride is the primary contaminant in a plume that extends from the former UST southeast to the vicinity of the Weaver Drive recharge basin, a distance of approximately 1,300 feet (**Figure 3**). The width of the plume as defined by the 50 ppb isocontour is approximately 120 feet. The plume migrates from the water table in the vicinity of EW-13 to a depth of approximately –20 feet mean sea level at EW-15 (**Figure 4**). **Table 2** summarizes January 2003 through February 2004 carbon tetrachloride and chloroform results for monitoring wells that exceed the NYS Ambient Water Quality Standards (AWQS) of 5 ppb for Carbon Tetrachloride and 7 ppb for Chloroform. The complete 2003 analytical results from the monitoring of wells in the Carbon Tetrachloride Program will be provided in the 2003 BNL Groundwater Status Report.

- Plume core well 85-98, located just south of the former UST, displayed carbon tetrachloride concentrations greater than 150,000 ppb in 1999. A decreasing trend **(Figure 5)** was observed in this well, beginning in 1999 with the start of groundwater pumping, and continued during 2001 with a concentration of 7 ppb reported during the fourth quarter. The concentration increased to 158 ppb during the fourth quarter of 2002 in response to the shutdown of EW-13 in early October of 2002. Concentrations since this time have declined and concentrations of carbon tetrachloride have been less than the groundwater standard of 5 ppb since July of 2003.

- Plume core well 85-17 is sited next to the BNL service station on Rochester Avenue and downgradient of the source area. Carbon tetrachloride concentrations have been declining

in this well from a high of 4,440 ppb in June 2000 to 140 ppb in February 2004 (**Figure 5**).

- Plume core well 85-161 is located approximately 120 feet downgradient from well 85-98. The declining carbon tetrachloride concentration trend in this well since 1999 continued, with a first quarter 2004 result of 11 ppb.

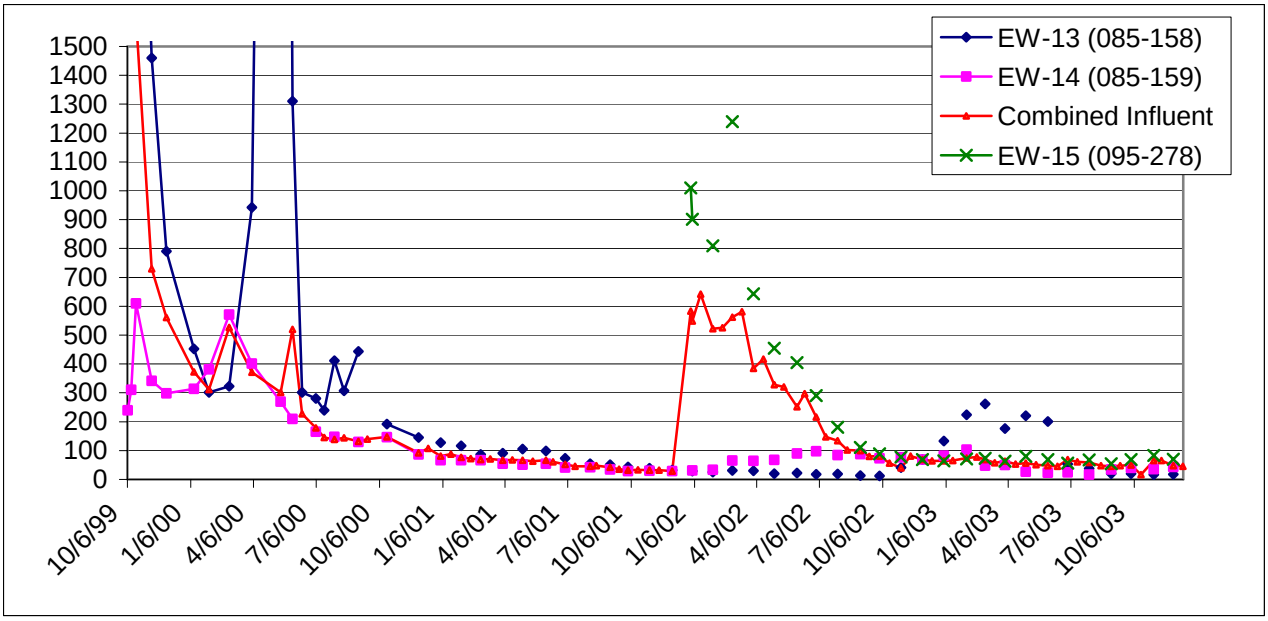
- Plume core well 95-183 is approximately 450 feet downgradient of EW-13. Carbon tetrachloride concentrations in this well have decreased from greater than 2,000 ppb in 2000 to 4.8 ppb during in February 2004.

- Plume core wells 95-277 and 95-279 were installed in 2001 after groundwater characterization of the downgradient segment of the plume. Carbon tetrachloride concentrations in well 095-277 have decreased significantly in the past year, from 1,860 ppb in February 2003 to 5.6 ppb in February 2004 (**Figure 5)**. Well 095-279, located approximately 100 feet northwest of EW-15, has shown reductions in carbon tetrachloride concentrations from 599 ppb in April 2002 to 79 ppb in February 2004.

The carbon tetrachloride concentrations in the plume core area have declined significantly in response to the removal action. Carbon tetrachloride was not detected in any of the bypass wells in the vicinity of Weaver Drive during 2003 and the first quarter of 2004, which indicate the plume is being controlled.

System Operational Data

The overall influent water quality to the carbon vessels continued to show a decrease in the concentrations of contaminants. The influent carbon tetrachloride concentration at the beginning of system operation in October 1999 was 11,000 ppb. The concentration was 46 ppb at the end of December 2003. A plot of this data and the individual extraction well data is shown below:



The mass of carbon tetrachloride removed from the aquifer was calculated using average flow rates for each monthly monitoring period and influent concentrations to the carbon treatment system. T**able 3** gives total pounds of mass of carbon tetrachloride removed by the treatment system; Approximately 342 pounds (about 26 gallons) of carbon tetrachloride were removed since the start of this removal action. A plot of this data is also shown in Section 2.3.

2.3 Groundwater Modeling

The BNL groundwater model was used to aid in:

(1) Evaluating the groundwater monitoring data to determine if source control has been achieved,
(2) Evaluating whether terminating the Carbon Tetrachloride groundwater treatment system in 2004 will jeopardize the OU III ROD cleanup goal of achieving MCLs within 30 years, and
(3) Determining if sufficient contingencies are in place to manage any uncertainties in the effectiveness of the Carbon Tetrachloride source control project.

Modeling approach

For this updated model assessment, the BNL "Onsite Sub-model" was used. This is a sub-model of the BNL Groundwater Model (AG&M, 1999).

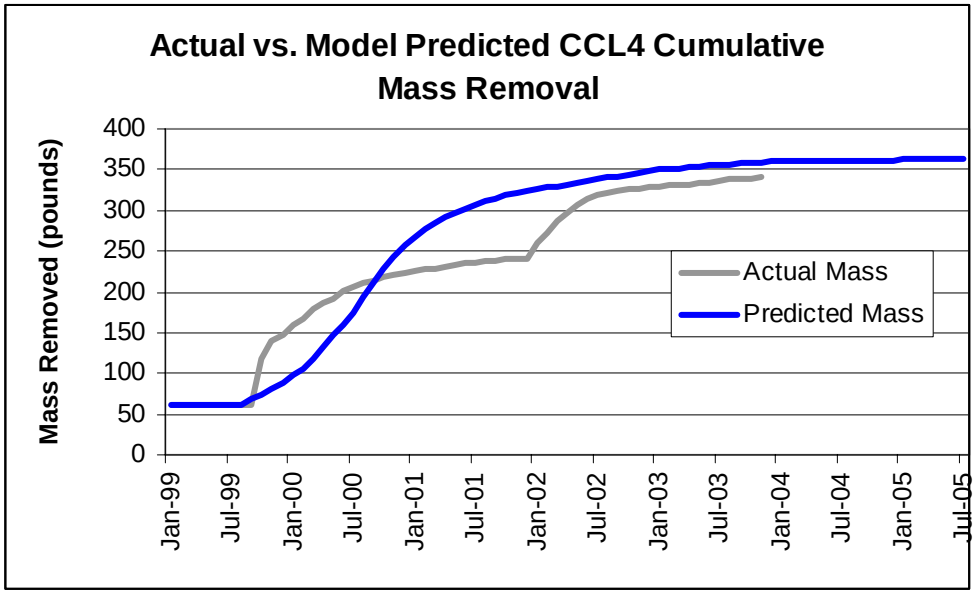
Because the Carbon Tetrachloride system is within 400 feet of the Building 96 groundwater treatment system, both systems are simulated in detail. This model includes the following features/assumptions:

- The shallow silt zone in the vicinity of the Building 96 source area
- Average 2002/2003 onsite water supply pumping and rainfall recharge data
- Cell sizes in the area of interest are approximately 50 by 50 feet
- Retardation factor is 1.1; dispersivity is assumed to be zero in all directions
- The initial plume concentrations were based on the 4th quarter 2002 plume maps presented in the 2002 BNL Groundwater Status report.
- No continuing source of Carbon Tetrachloride or significant residual contamination source in the aquifer or vadose zone.

The starting time for the simulation was January 2003. The Carbon Tetrachloride system was simulated as follows based on actual pumping records. For the simulation, it was assumed that the Carbon Tet system ceases to operate in April 2004. This is conservative as the system will continue operations until at least August 1, 2004.

Extraction Well Number	January 2003 – June 2003	July 2003- December 2003	January 2004- March 2004	April 2004 – April 2024
EW-13	0 gpm	31 gpm	30 gpm	0 gpm
EW-14	14 gpm	0 gpm	0 gpm	0 gpm
EW-15	40 gpm	33 gpm	40 gpm	0 gpm

The model predictions for December 2003 were compared to the fourth quarter 2003 plume map as a simple means of solute transport calibration. This comparison is shown in **Figure 6**. There is good agreement between the two. The predicted mass removal vs. the measured mass removal for the Carbon Tetrachloride system is shown below. The predictions and the observations are very close. The model is able to provide a reasonable prediction of the aquifer cleanup performance.



What do the data and the model tell us about the source?

Several conclusions can be drawn from the data and **Figures 6** and **7**. They include:

- Monitoring well data in the vicinity of the tank spill area has displayed minor concentration rebound when either EW-13 or EW-14 is turned off. The highest Carbon Tetrachloride concentration measured in February, 2004 is 160 ppb in wells 085-162 and 085-237.

- While the model does not predict residual contamination in the spill area, the concentrations observed in this area and the minor rebound effect observed does suggest that a weak source of residual contamination remains. Model predictions suggest that this residual contamination will not delay achieving the OU III cleanup goals and will not contribute to a significant spread in contamination.

- The peak observed concentration in the source area has been reduced from 179,000 ppb to 160 ppb in February 2004, about a 99.9% reduction. The model predicts that approximately 93 to 95% percent of the mass has been removed.

- The cumulative mass removal curve shows that the treatment system has reached a near asymptotic condition and a point of significantly diminishing returns.

- Both the data and model predictions show a very small area of contamination greater than 100 ppb. The measured peak concentration in the 4th quarter 2003 data was 160 ppb. The model predicted peak concentration for December 2003 was 100 ppb.

- The operation of the Carbon Tetrachloride groundwater remediation system has controlled the spread of contamination and has dramatically reduced the contamination concentrations. The system has met its objective of controlling and mitigating this source area.

If the Carbon Tetrachloride System is shutdown in 2004, will it jeopardize the OU III cleanup goals?

The groundwater model simulation continued through 2017 assuming that the Carbon Tetrachloride system ceased operation in April 2004. **Figure 7** shows the model predicted concentrations in December 2007. The predicted peak concentration is less than 50 ppb and is still in the center of the site. The center of mass of this contamination is predicted to be in the vicinity of the HFBR pump and recharge wells EW-9, EW-10, and EW-11), which are currently in standby (on Princeton Avenue). For the simulation, it is assumed that these HFBR wells are not pumping.

Figure 8 shows the model predicted concentrations in April 2017 (Note: the map scale and frame changes from Figure 7 to Figure 8). The contamination is predicted to be 5-10 ppb in several very small areas and still north of the Middle Road groundwater treatment system. The model predicts that DWS will be reached in about 13 to 15 years. These model simulations predict that the OU III cleanup goals will be achieved with the shutdown of the Carbon Tetrachloride system in April 2004.

What contingencies are in place to manage any model uncertainties?

Groundwater monitoring of this plume will continue for several more years. These wells are currently sampled on a quarterly basis. The sampling frequency of these wells is evaluated on an If the rate of attenuation is slower than predicted or if a significant source emerges (unlikely), the Carbon Tetrachloride system can be restarted. In addition, two other groundwater treatment systems lie down gradient of the contamination. Since the HFBR wells are in standby, the Middle Road system is likely the best-suited barrier to capture any contamination that does not attenuate at the predicted rate.

There are sufficient contingencies to address any model uncertainties.

Based upon the groundwater modeling this system has achieved the Removal Action objectives of source control and source reduction and the OU III cleanup goals will be met.

3.0 CONCLUSIONS AND RECOMMENDATIONS

- Maximum contaminant levels at the carbon tetrachloride groundwater removal action have been reduced from 179,000 ppb in 1998 down to 160 ppb in 2004, a reduction of greater then 99.9%.
- The total mass of carbon tetrachloride removed since the start of this removal action is approximately 342 pounds (or about 26 gallons).
- The mass removal rates from the treatment system have essentially reached an asymptotic condition. During initial operations of this system it was removing over 7 pounds of carbon tetrachloride per day. For the past year this rate has been steady at about .04 pounds per day.
- The system has achieved the objectives outlined in the Action Memorandum for this project of removing as much of the high concentrations of carbon tetrachloride in the groundwater as possible before it migrates away from this area.
- The groundwater modeling predicts that shutdown of this system is consistent with the remedial objectives for OU III ROD and that MCLs will be met in groundwater in 13 to 15 more years (2017-2019).
- The system will remain in standby mode for several more years to verify that no significant rebounds in contaminant concentrations occur.
- If a significant rebound in concentrations is observed the system may be restarted.

Based upon the above discussions it is recommended that the carbon tetrachloride groundwater treatment system be shutdown on August 1, 2004. The system will remain in standby

(operationally ready) for several years and if no significant rebounds in concentrations are observed a Petition for Closure of this system will be submitted to the EPA and NYSDEC.

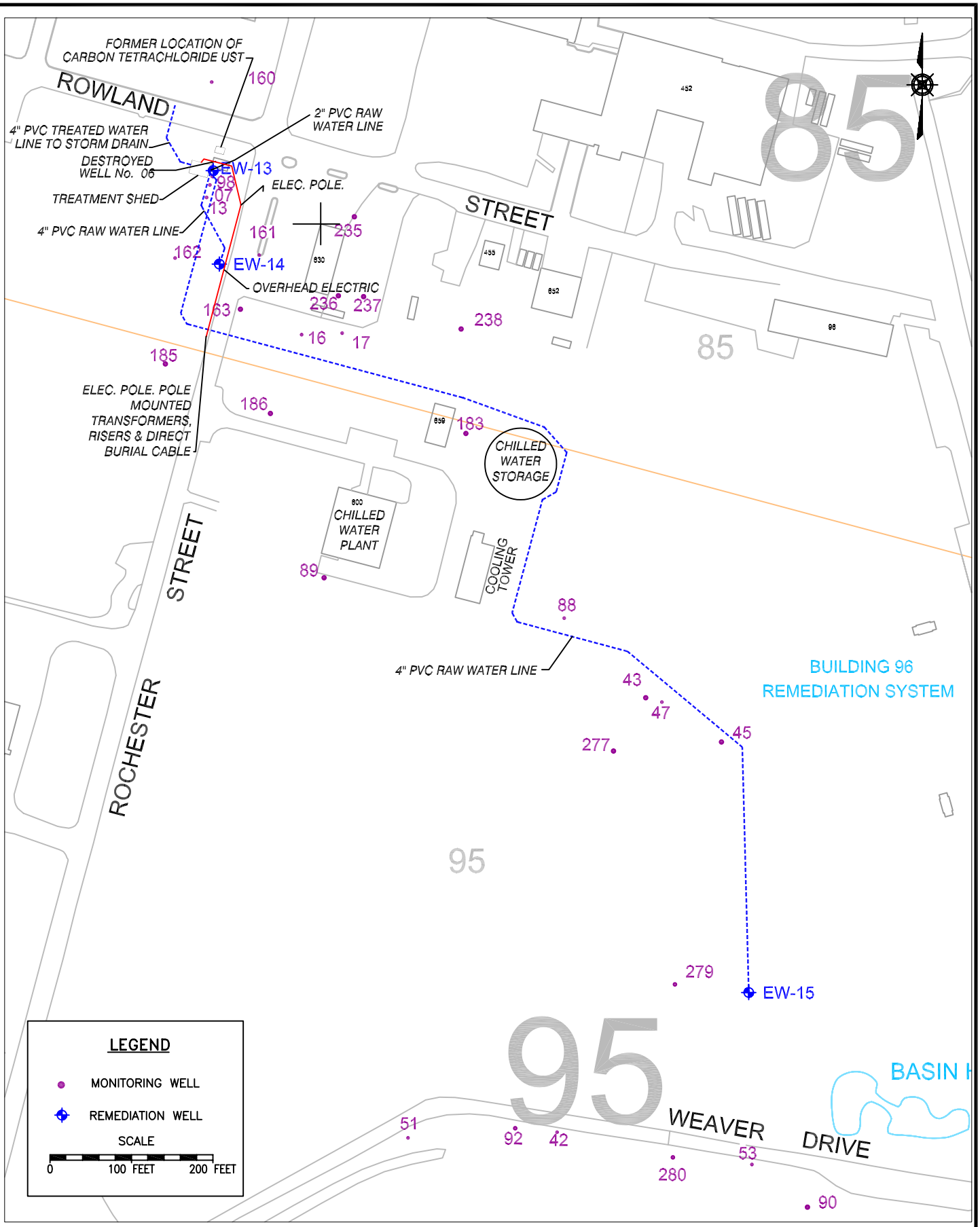
REFERENCES

BNL, Operable Unit III Record Of Decision, June 2000

BNL, Environmental Restoration Division, Final Action Memorandum, Carbon Tetrachloride Tank Groundwater Removal Action, BNL, January 1999

BNL, Environmental Restoration Division, 2002 Annual Groundwater Status Report

FIGURES



T:\Prj\Managers\Racaniello\ccl14\Petfor\Shutdown\Figures\Fig 1

BROOKHAVEN NATIONAL LABORATORY GROUNDWATER PROTECTION PROGRAM	TITLE: OU III CARBON TETRACHLORIDE GROUNDWATER REMOVAL ACTION PROCESS LAYOUT AND LOCATION Carbon Tetrachloride Petition for Shutdown	DWN: SRW	VT: HZ.:	DATE: 07/16/03
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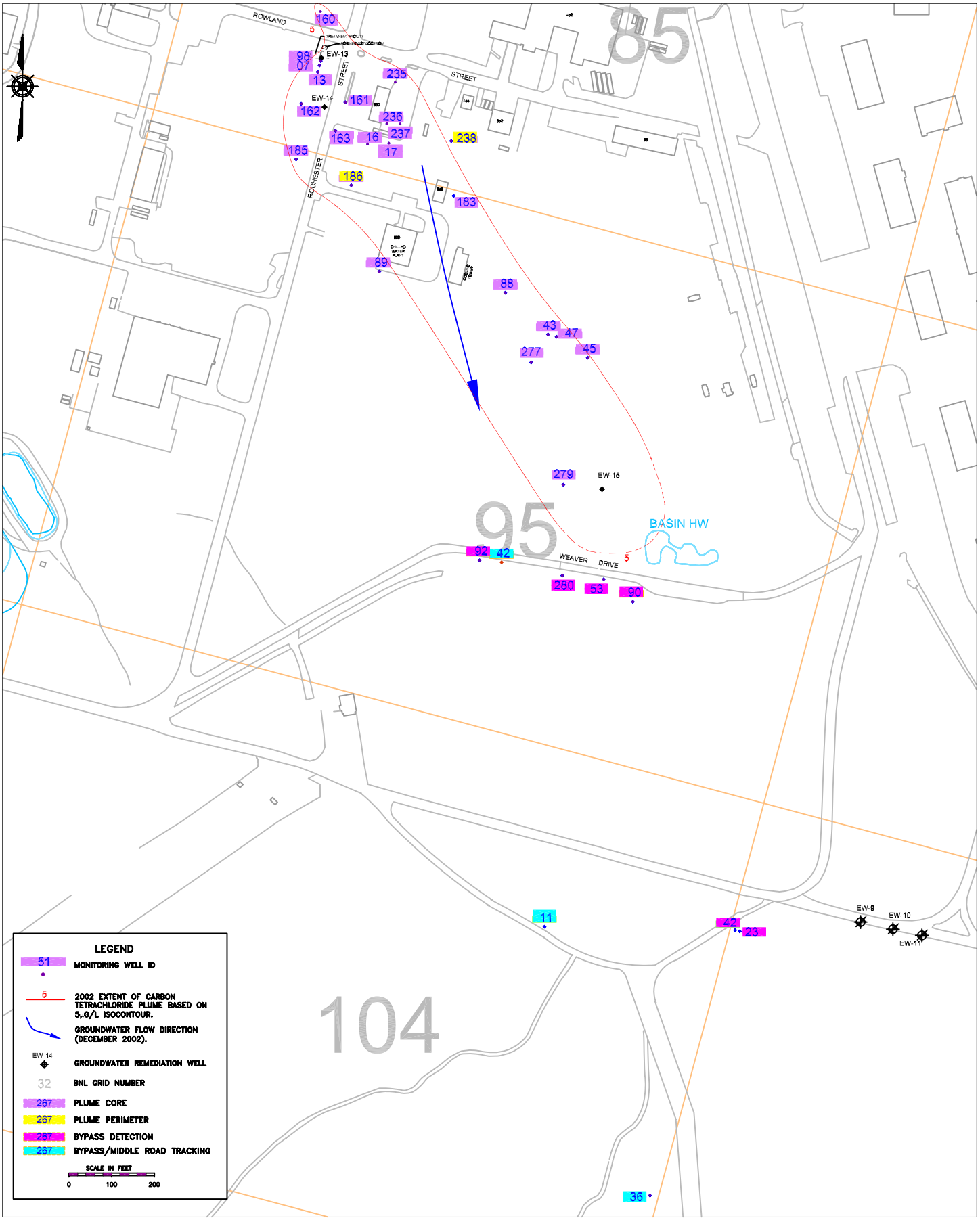

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BROOKHAVEN NATIONAL LABORATORY

GROUNDWATER PROTECTION PROGRAM

TITLE:

OU III CARBON TETRACHLORIDE MONITORING WELL LOCATIONS

Carbon Tetrachloride Petition for Shutdown

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
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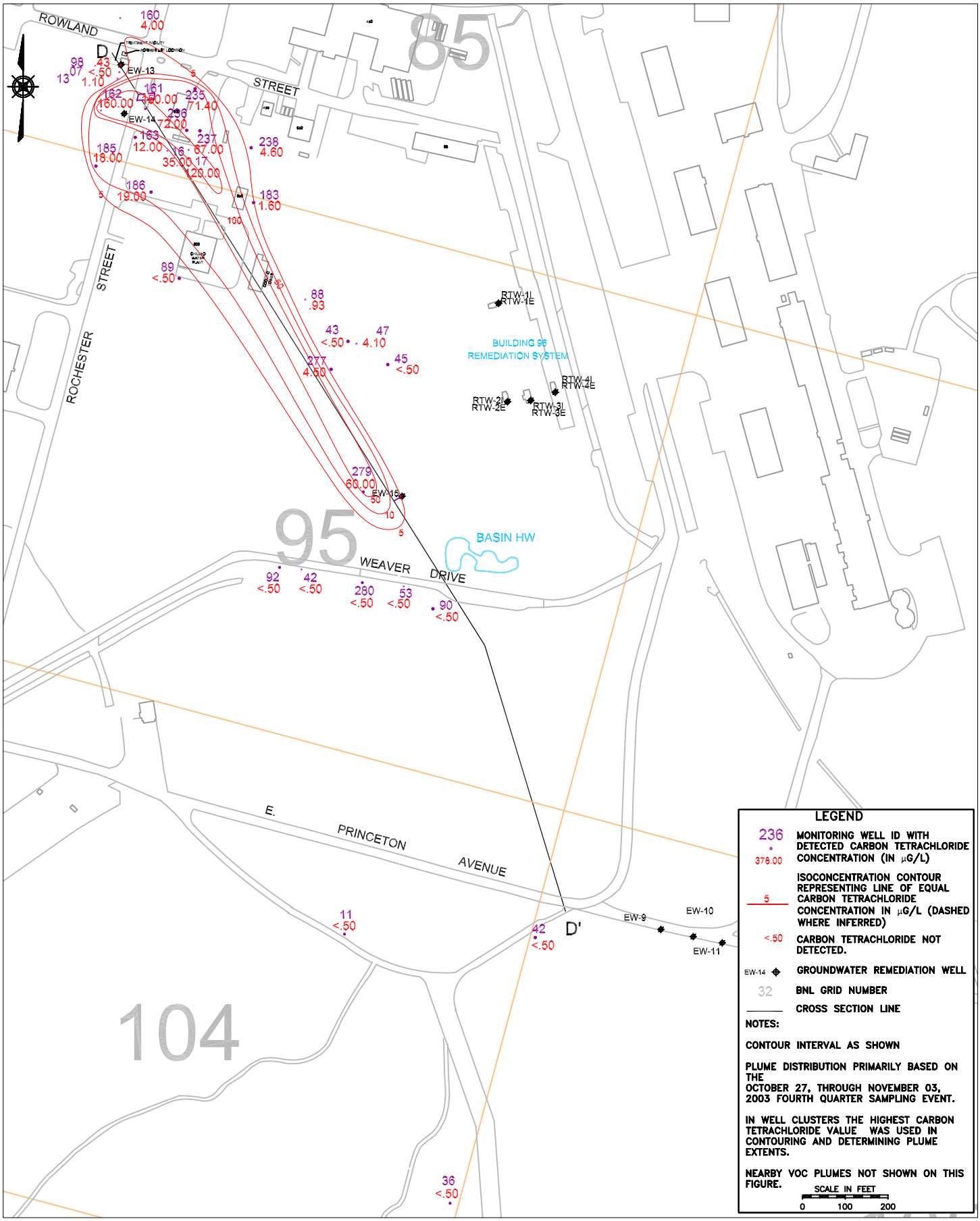
CHKD:	APPD:	REV.:	NOTES:
WRD	VJR	1	

FIGURE NO.: Figure 2



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BROOKHAVEN NATIONAL LABORATORY
GROUNDWATER PROTECTION PROGRAM

TITLE:

OU III CARBON TETRACHLORIDE PLUME DISTRIBUTION

Carbon Tetrachloride Petition For Shutdown

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
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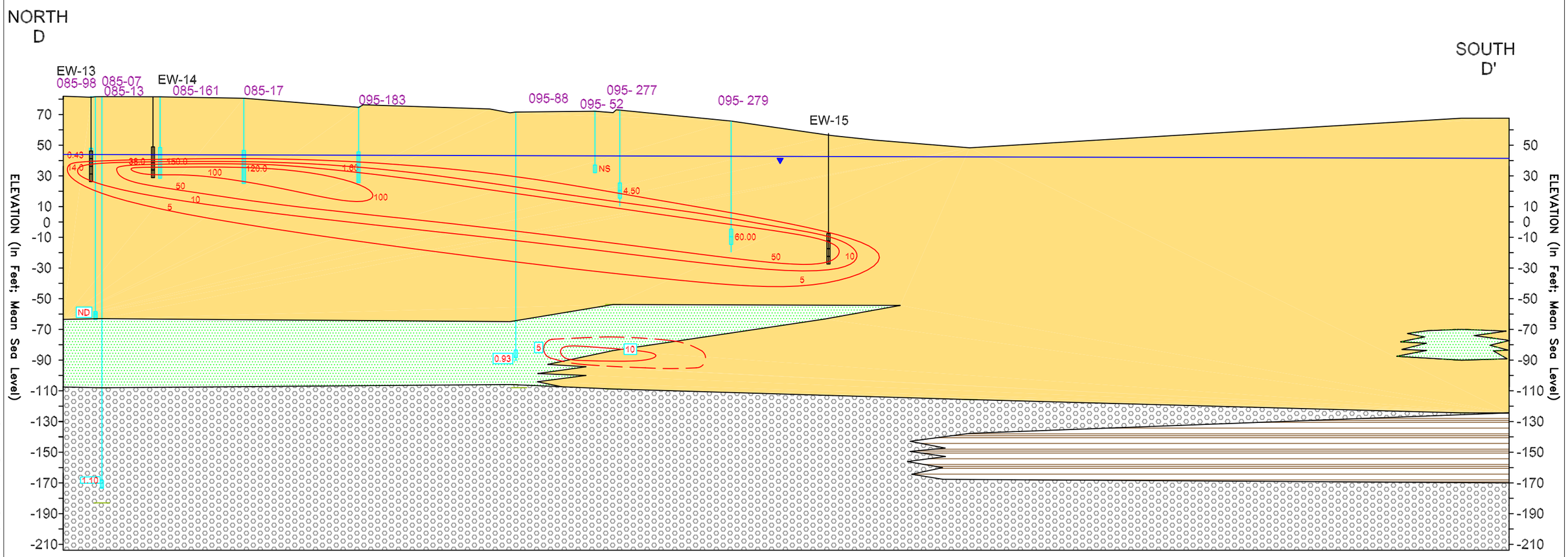
WRD	VJR	0	DRAFT

FIGURE NO.: 3



LEGEND

Upper Glacial aquifer
- UG Upper Glacial Sands
- UC Upper Glacial Silts & Clays
- UU Upton Unit

Gardiners Clay
- GL Gardiners Clay
- GS Gardiners Clay – Silt

0 50 100
FEET

Magothy aquifer
- MA Magothy Sands and Clay
- MB Magothy Brown Clay
- MC Magothy Clays (undiff)

000–130 BNL Well ID

0.79 Monitoring Well CCL4 Concentration (µG/L)

50 CCL4 Contour (µG/L) (Dashed Where Inferred)

Monitoring Well Screen

Extraction Well Screen

Water Table As Of December 16–19, 2003

1.30
1.86
Vertical profile location and TVOC Concentration (µG/L)

NOTES:

1) GEOLOGIC INFORMATION SHOWN IS BASED ON ADDITIONAL EXPLORATIONS (e.g., HYDROPUNCHES, GEOPROBES, VERTICAL PROFILES, AND/OR TEST WELLS) DOCUMENTED IN PREVIOUS, MORE DETAILED REPORTS.

2) PLUME DISTRIBUTION IS BASED ON FOURTH QUARTER 2003 OUIII CARBON TETRACHLORIDE SYSTEM SAMPLING EVENT.

3) CONTOUR INTERVAL IS AS SHOWN.

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BROOKHAVEN NATIONAL LABORATORY

GROUNDWATER PROTECTION PROGRAM

TITLE:

OU III CARBON TETRACHLORIDE HYDROGEOLOGIC CROSS SECTION (D–D')

2003 BNL GROUNDWATER STATUS REPORT

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
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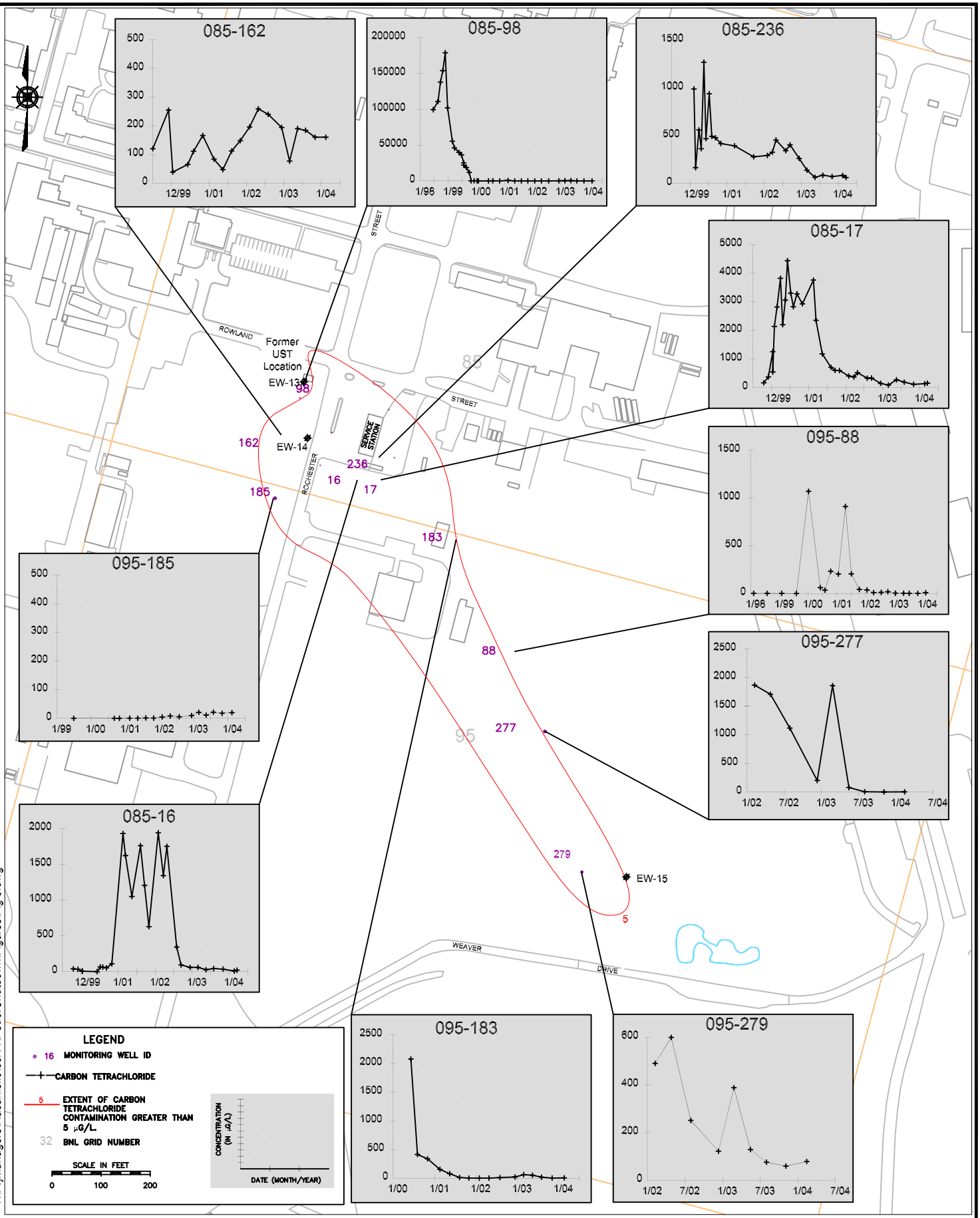

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BROOKHAVEN NATIONAL LABORATORY

GROUNDWATER PROTECTION PROGRAM

TITLE:

OU III CARBON TETRACHLORIDE HISTORICAL TRENDS

Carbon Tetrachloride Petition for Shutdown

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
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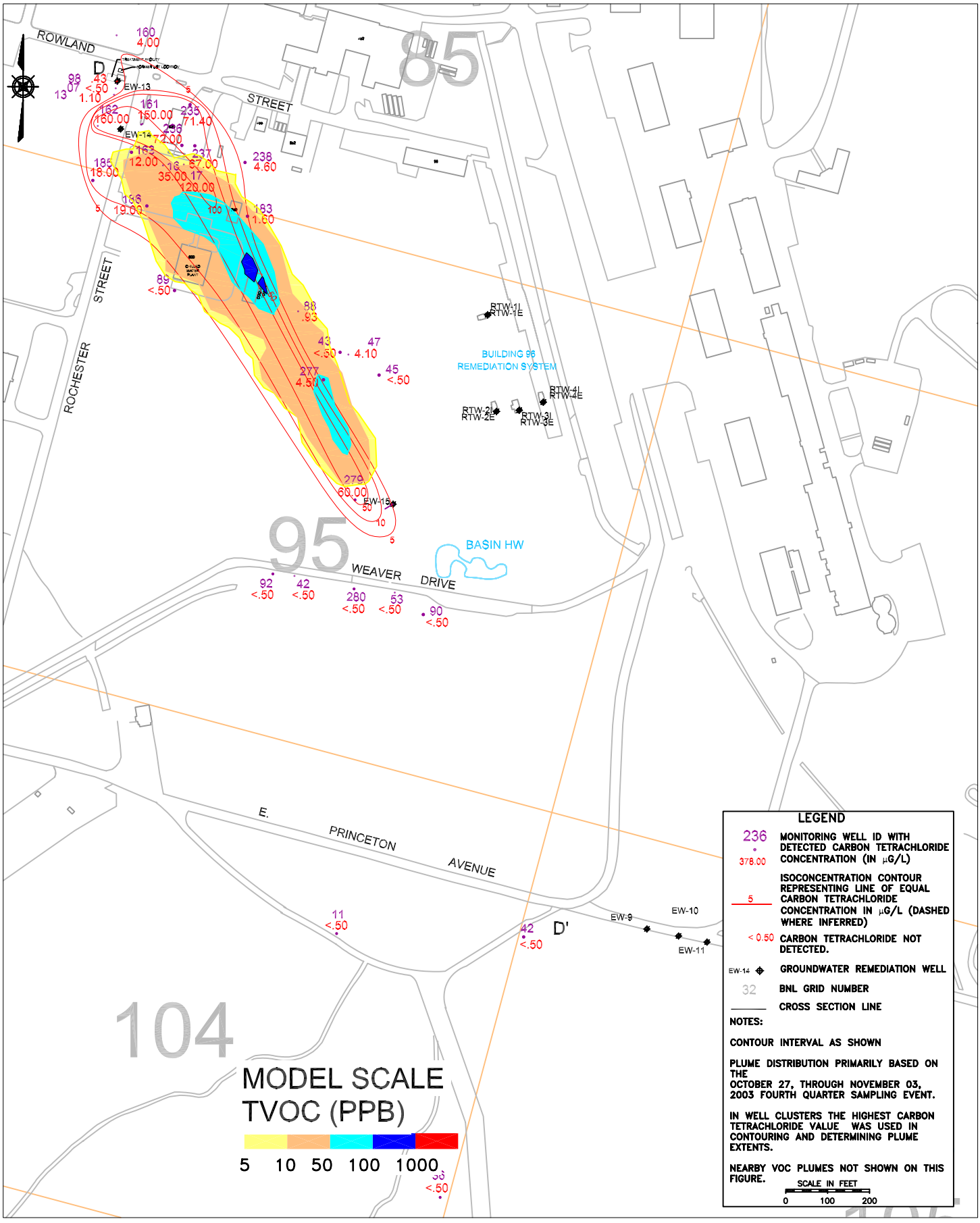

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BROOKHAVEN NATIONAL LABORATORY

GROUNDWATER PROTECTION PROGRAM

TITLE:

OU III CARBON TETRACHLORIDE
Dec. 2003 Observed vs. Model
Carbon Tetrachloride Petition for Shutdown

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
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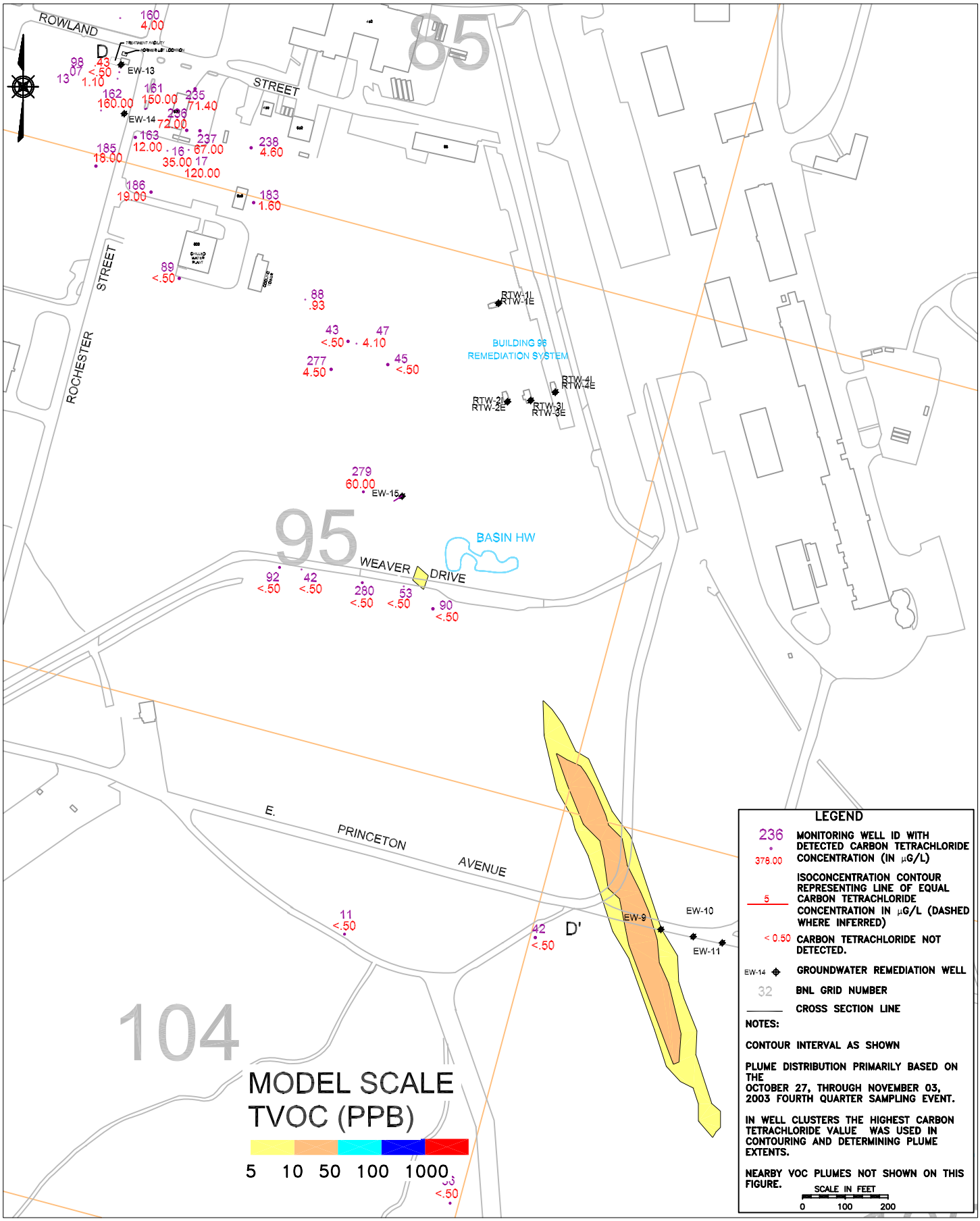
CHKD:	APPD:	REV.:	NOTES:
	VJR	0	

FIGURE NO.: Figure 6



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BROOKHAVEN NATIONAL LABORATORY
GROUNDWATER PROTECTION PROGRAM

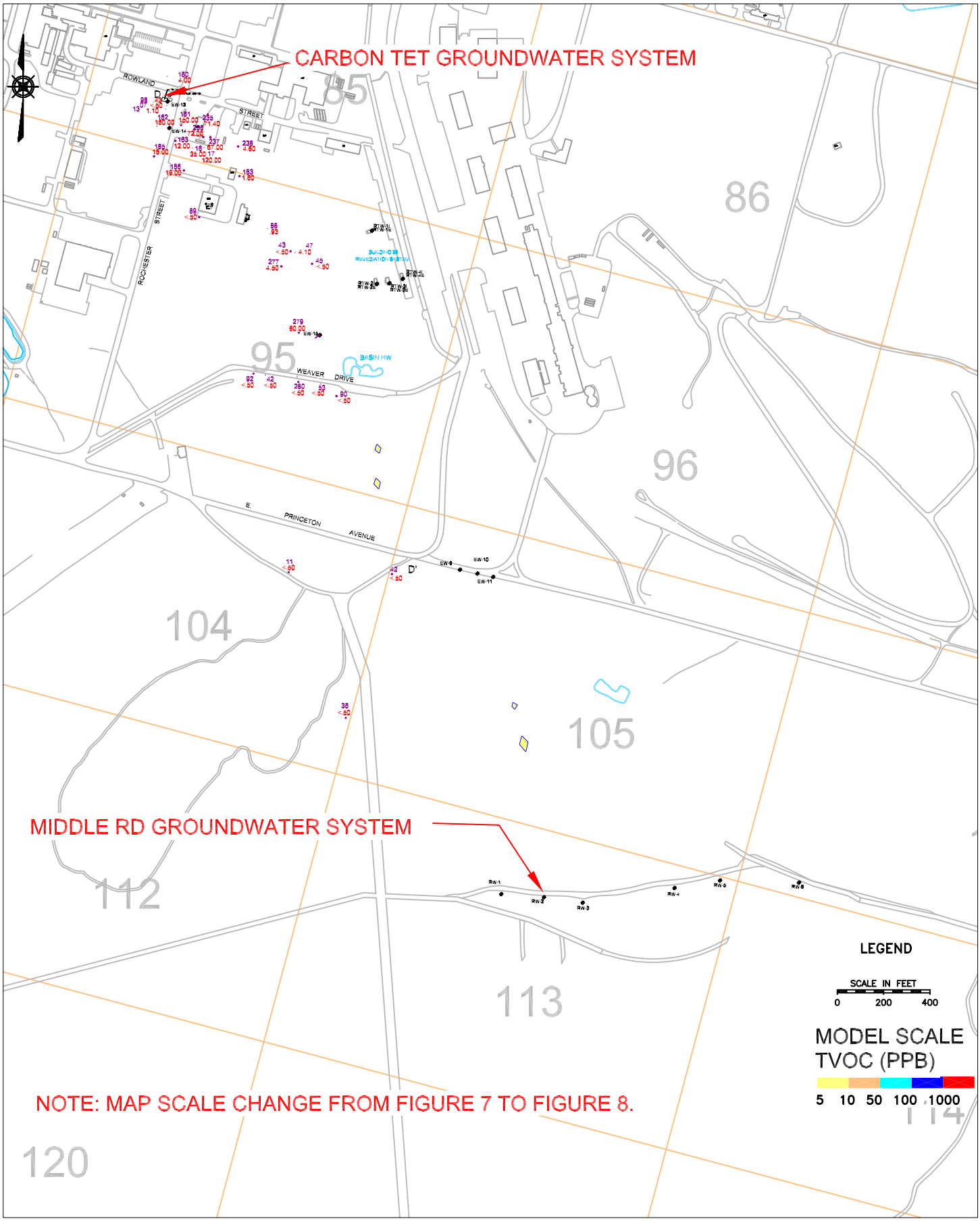
TITLE:

OU III CARBON TETRACHLORIDE MODEL PREDICTION – DEC. 2007

Carbon Tetrachloride Petition for Shutdown

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
DBB	–	03/15/04	7280
CHKD:	APPD:	REV.:	NOTES:
	VJR	0	

FIGURE NO.: Figure 7



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BROOKHAVEN NATIONAL LABORATORY

GROUNDWATER PROTECTION PROGRAM

TITLE:

OU III CARBON TETRACHLORIDE MODEL PREDICTION – DEC. 2017

Carbon Tetrachloride Petition for Shutdown

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
DBB	–	03/15/04	7280
CHKD:	APPD:	REV.:	NOTES:
	VJR	0	

FIGURE NO.: 8

TABLES

Table 1. OU III Carbon Tetrachloride Source Control Monitoring Well Network

WELL	SUBUNIT	SCREEN ZONE *	AQUIFER SCREENED
085-07	Plume Perimeter	140-145	Deep Upper Glacial
085-13	Plume Perimeter	250-255	Magothy
085-16	Plume Core	34-54	Shallow Upper Glacial
085-17	Plume Core	34-54	Shallow Upper Glacial
085-98	Plume Perimeter	38-43?	Shallow Upper Glacial
085-160	Plume Core	34-54	Shallow Upper Glacial
085-161	Plume Perimeter	33-53	Shallow Upper Glacial
085-162	Plume Perimeter	29-49	Shallow Upper Glacial
085-163	Plume Core	29-49	Shallow Upper Glacial
085-238	Plume Core	25-45	Shallow Upper Glacial
095-183	Plume Perimeter	29-49	Shallow Upper Glacial
095-185	Plume Perimeter	32-62	Shallow Upper Glacial
095-186	Plume Perimeter	30-60	Shallow Upper Glacial
085-235	Plume Perimeter	35-55	Shallow Upper Glacial
085-236	Plume Core	35-55	Shallow Upper Glacial
085-237	Plume Core	35-55	Shallow Upper Glacial
095-43	Plume Core	108-113	Mid Upper Glacial
095-45	Secondary Plume Core	108-113	Shallow Upper Glacial
095-47	Plume Core	195-200	Deep Upper Glacial
095-88	Plume Core	155-160	Deep Upper Glacial
095-89	Plume Perimeter	155-165	Deep Upper Glacial
095-277	Plume Core	47-57	Shallow Upper Glacial
095-279	Plume Core	70-80	Mid Upper Glacial
095-42	Bypass	100-105	Shallow Upper Glacial
095-53	Bypass	87-92	Mid Upper Glacial
095-90	Bypass	98.5-108.5	Shallow Upper Glacial
095-92	Bypass	116-126	Shallow Upper Glacial
095-280	Bypass	85-95	Mid Upper Glacial
104-11	MRT	185-195	Deep Upper Glacial
105-23	MRT	175-185	Deep Upper Glacial
105-42	MRT	145-150	Deep Upper Glacial
104-36	MRT	126-146	Deep Upper Glacial

* Feet below ground surface
MRT: Middle Road Tracking

Table 2. Summary of Carbon Tetrachloride and Chloroform Detections
Exceeding Groundwater Standards in Monitoring Wells

Site ID: 085-16						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/25/2003	**60.4**	0.5	UG/L	45	
Chloroform	2/25/2003	**8**	0.5	UG/L	45	
Carbon tetrachloride	5/15/2003	**27**	0.5	UG/L	40	
Chloroform	5/15/2003	**5.7**	0.5	UG/L	40	
Carbon tetrachloride	7/31/2003	**42.9**	0.5	UG/L	45	
Chloroform	7/31/2003	**9.7**	0.5	UG/L	45	
Carbon tetrachloride	10/31/2003	**35**	0.5	UG/L	45	
Chloroform	10/31/2003	**8.7**	0.5	UG/L	45	
Site ID: 085-160						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/24/2003	**20.6**	0.5	UG/L	44	
Carbon tetrachloride	5/14/2003	**6.6**	0.5	UG/L	44	
Carbon tetrachloride	7/30/2003	**20.4**	0.5	UG/L	44	
Site ID: 085-161						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/24/2003	**22.6**	0.5	UG/L	43	
Chloroform	2/24/2003	**6.7**	0.5	UG/L	43	
Carbon tetrachloride	5/15/2003	**11.9**	0.5	UG/L	43	
Carbon tetrachloride	7/31/2003	**92.1**	0.5	UG/L	43	
Chloroform	7/31/2003	**18**	0.5	UG/L	43	
Carbon tetrachloride	10/31/2003	**150**	5	UG/L	43	D
Chloroform	10/31/2003	**38**	0.5	UG/L	43	
Site ID: 085-162						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/24/2003	**76.6**	0.5	UG/L	39	
Chloroform	2/24/2003	**11.5**	0.5	UG/L	39	
Carbon tetrachloride	5/14/2003	**190**	2.5	UG/L	39	D
Chloroform	5/14/2003	**22.6**	0.5	UG/L	39	
Carbon tetrachloride	7/30/2003	**184**	5	UG/L	39	D
Chloroform	7/30/2003	**22.2**	0.5	UG/L	39	
Carbon tetrachloride	10/31/2003	**160**	12	UG/L	39	D
Chloroform	10/31/2003	**18**	0.5	UG/L	39	
Site ID: 085-163						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/24/2003	**84.6**	0.5	UG/L	39	
Chloroform	2/24/2003	**12.1**	0.5	UG/L	39	
Carbon tetrachloride	7/30/2003	**55.1**	0.5	UG/L	39	
Chloroform	7/30/2003	**8.2**	0.5	UG/L	39	
Carbon tetrachloride	10/31/2003	**12**	0.5	UG/L	39	

Table 2. Summary of Carbon Tetrachloride and Chloroform Detections
Exceeding Groundwater Standards in Monitoring Wells

Site ID: 085-17						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/25/2003	**92.6**	2	UG/L	45	D
Chloroform	2/25/2003	**15**	0.5	UG/L	45	
Carbon tetrachloride	7/31/2003	**194**	5	UG/L	45	D
Chloroform	7/31/2003	**27.2**	0.5	UG/L	45	
Carbon tetrachloride	10/31/2003	**120**	5	UG/L	45	D
Chloroform	10/31/2003	**22**	0.5	UG/L	45	
Site ID: 085-236						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/25/2003	**139**	2.5	UG/L	42.5	D
Chloroform	2/25/2003	**15.6**	0.5	UG/L	42.5	
Carbon tetrachloride	5/15/2003	**64**	0.5	UG/L	42.5	
Chloroform	5/15/2003	**10.4**	0.5	UG/L	42.5	
Carbon tetrachloride	7/31/2003	**86.1**	0.5	UG/L	42.5	
Chloroform	7/31/2003	**14.5**	0.5	UG/L	42.5	
Carbon tetrachloride	10/31/2003	**72**	2.5	UG/L	42.5	D
Chloroform	10/31/2003	**16**	0.5	UG/L	42.5	

Table 2. Summary of Carbon Tetrachloride and Chloroform Detections
Exceeding Groundwater Standards in Monitoring Wells

Site ID: 085-237						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/25/2003	**61.4**	0.5	UG/L	42.5	
Chloroform	2/25/2003	**6.1**	0.5	UG/L	42.5	
Carbon tetrachloride	5/15/2003	**153**	1	UG/L	42.5	D
Chloroform	5/15/2003	**16.5**	0.5	UG/L	42.5	
Carbon tetrachloride	7/31/2003	**114**	5	UG/L	42.5	D
Chloroform	7/31/2003	**17**	0.5	UG/L	42.5	
Carbon tetrachloride	10/31/2003	**67**	2.5	UG/L	42.5	D
Chloroform	10/31/2003	**15**	0.5	UG/L	42.5	
Site ID: 085-238						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/25/2003	**5.8**	0.5	UG/L	35	
Carbon tetrachloride	5/14/2003	**5.6**	0.5	UG/L	35	
Site ID: 085-98						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/24/2003	**237**	5	UG/L	37.5	D
Chloroform	2/24/2003	**55.6**	0.5	UG/L	37.5	
Carbon tetrachloride	5/14/2003	**344**	5	UG/L	37.5	D
Chloroform	5/14/2003	**85.3**	0.5	UG/L	37.5	
Site ID: 095-183						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/25/2003	**60.6**	0.5	UG/L	39	
Chloroform	2/25/2003	**5.7**	0.5	UG/L	39	
Carbon tetrachloride	5/14/2003	**51.4**	0.5	UG/L	39	
Chloroform	5/14/2003	**6.4**	0.5	UG/L	39	
Carbon tetrachloride	8/1/2003	**16.6**	0.5	UG/L	39	
Site ID: 095-185						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/24/2003	**21.1**	0.5	UG/L	47	
Carbon tetrachloride	5/14/2003	**11.4**	0.5	UG/L	47	
Carbon tetrachloride	7/30/2003	**21.6**	0.5	UG/L	47	
Carbon tetrachloride	10/31/2003	**18**	0.5	UG/L	47	
Site ID: 095-186						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/24/2003	**12.9**	0.5	UG/L	45	
Chloroform	2/24/2003	**47.7**	0.5	UG/L	45	
Carbon tetrachloride	5/15/2003	**20.4**	0.5	UG/L	45	
Chloroform	5/15/2003	**16.4**	0.5	UG/L	45	
Carbon tetrachloride	7/30/2003	**15.1**	0.5	UG/L	45	
Chloroform	7/30/2003	**5.6**	0.5	UG/L	45	
Carbon tetrachloride	10/31/2003	**19**	0.5	UG/L	45	
Site ID: 095-277						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/24/2003	**1860**	25	UG/L	52	D
Chloroform	2/24/2003	**9.6**	0.5	UG/L	52	
Carbon tetrachloride	5/15/2003	**81.1**	0.5	UG/L	52	
Carbon tetrachloride	7/31/2003	**7.4**	0.5	UG/L	52	

Table 2. Summary of Carbon Tetrachloride and Chloroform Detections
Exceeding Groundwater Standards in Monitoring Wells

Site ID: 095-279						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	2/24/2003	**388**	10	UG/L	75	D
Chloroform	2/24/2003	**7.6**	0.5	UG/L	75	
Carbon tetrachloride	5/15/2003	**129**	1	UG/L	75	D
Carbon tetrachloride	8/1/2003	**76**	0.5	UG/L	75	
Carbon tetrachloride	11/3/2003	**60**	1	UG/L	75	D
Site ID: 095-47						
Chemical Name	**Sample Date**	**Value**	**Det. Limit**	**Units**	**Depth**	**Qual.**
Carbon tetrachloride	1/21/2003	**11.6**	0.5	UG/L	197.5	
Carbon tetrachloride	4/30/2003	**8.6**	0.5	UG/L	197.5	
Carbon tetrachloride	8/1/2003	**7.7**	0.5	UG/L	197.5	
Tetrachloroethylene	5/15/2003	**5.3**	0.5	UG/L	147.5	

Table 3
Cumulative Mass Removal

DATE	FLOW[1] (GPM)	CCL4[2] (PPB)	LBS/DAY[3]	CUM. LBS[4]
1/29/1999	--	--	--	61.10
10/6/1999	58	11000.0	7.66	61.10
10/11/1999	58	2400.0	1.67	99.41
10/14/1999	58	1800.0	1.25	104.43
10/18/1999	58	1660.0	1.16	109.44
10/25/1999	58	1190.0	0.83	117.54
11/3/1999	54	848.0	0.55	125.00
11/10/1999	54	729.0	0.47	128.85
12/2/1999	60	561.0	0.40	139.25
12/22/1999	60	587.0	0.42	147.33
1/11/2000	59	373.0	0.26	155.79
1/18/2000	59	151.0	0.11	157.64
2/1/2000	65	311.0	0.24	159.14
2/15/2000	65	384.0	0.30	162.54
3/1/2000	58	527.0	0.37	167.04
3/15/2000	58	508.0	0.35	172.18
4/3/2000	63	371.0	0.28	178.90
4/17/2000	63	266.0	0.20	182.83
5/1/2000	57	226.0	0.15	185.65
5/15/2000	57	302.0	0.21	187.81
6/1/2000	73	520.0	0.46	191.33
6/15/2000	73	227.0	0.20	197.71
7/5/2000	82	178.0	0.18	201.69
7/17/2000	82	145.0	0.14	203.79
8/1/2000	76	139.0	0.13	205.94
8/15/2000	76	144.0	0.13	207.71
9/5/2000	73	132.0	0.12	210.47
9/18/2000	73	140.0	0.12	211.98
9/30/2000	73	NA	N/A	213.45
10/2/2000	77	141	0.13	213.71
10/16/2000	77	148	0.14	215.54
11/1/2000	73	147	0.13	217.73
11/17/2000	73	97.8	0.09	219.79
12/1/2000	63	91.9	0.07	220.99
12/15/2000	63	107	0.08	221.96
12/31/2000	63	107	0.08	223.26
1/2/2001	72	81	0.07	223.42
1/17/2001	72	87.6	0.08	224.47
2/1/2001	78	76.8	0.07	225.61
2/15/2001	78	72.4	0.07	226.61
3/1/2001	68	68.9	0.06	227.56
3/15/2001	68	71.3	0.06	228.35
3/31/2001	68	71.3	0.06	229.28
4/2/2001	72	66.9	0.06	229.40

Table 3
Cumulative Mass Removal

DATE	FLOW[1] (GPM)	CCL4[2] (PPB)	LBS/DAY[3]	CUM. LBS[4]
4/16/2001	72	67.4	0.06	230.21
5/1/2001	76	67	0.06	231.08
5/16/2001	76	62.9	0.06	232.00
6/4/2001	83	66.6	0.07	233.09
6/14/2001	83	61.1	0.06	233.76
6/30/2001	83	61.1	0.06	234.73
7/2/2001	80	52.3	0.05	234.85
7/15/2001	80	45	0.04	235.50
8/2/2001	80	45	0.04	236.28
8/15/2001	80	47.3	0.05	236.85
9/2/2001	80	41.6	0.04	237.66
9/15/2001	80	35.2	0.03	238.18
10/1/2001	75	32.4	0.03	238.72
10/15/2001	75	33.6	0.03	239.13
11/1/2001	81	32.3	0.03	239.65
11/15/2001	81	31.9	0.03	240.09
12/4/2001	83	28.8	0.03	240.68
12/31/2001	78	583	0.55	241.45
1/2/2002	78	549	0.51	242.54
1/14/2002	78	642	0.60	248.72
2/1/2002	72	522	0.45	259.54
2/15/2002	72	525	0.45	265.86
3/1/2002	68	562	0.46	272.22
3/15/2002	68	581	0.47	278.64
4/1/2002	77	385	0.36	286.71
4/15/2002	77	417	0.39	291.69
5/1/2002	71	328	0.28	297.86
5/15/2002	71	320	0.27	301.78
6/3/2002	74	252	0.22	306.96
6/14/2002	74	297	0.26	309.43
7/1/2002	69	216	0.18	313.91
7/15/2002	69	148	0.12	316.42
8/1/2002	68	134	0.11	318.50
8/15/2002	68	102	0.08	320.04
9/3/2002	72	99.3	0.09	321.62
9/16/2002	72	80	0.07	322.74
10/1/2002	60	80.5	0.06	323.77
10/15/2002	60	56	0.04	324.59
11/1/2002	52	40.3	0.03	325.27
11/15/2002	52	81	0.05	325.62
12/2/2002	51	68.7	0.04	326.48
12/16/2002	51	64.4	0.04	327.07
1/2/2003	48	64.2	0.04	327.74
1/15/2003	48	64.9	0.04	328.22
2/4/2003	46	73.9	0.04	328.97
2/19/2003	46	78.1	0.04	329.58
3/3/2003	32	68.2	0.03	330.10
3/17/2003	32	57.7	0.02	330.47
4/1/2003	69	62.7	0.05	330.80
4/16/2003	69	52.8	0.04	331.58
5/1/2003	71	56	0.05	332.24
5/16/2003	71	51.4	0.04	332.95
6/2/2003	74	47.9	0.04	333.70
6/16/2003	74	45	0.04	334.30
7/1/2003	52	68.9	0.04	334.90
7/15/2003	52	60.1	0.04	335.50
8/1/2003	66	58.6	0.05	336.14

Table 3
Cumulative Mass Removal

DATE	FLOW[1] (GPM)	CCL4[2] (PPB)	LBS/DAY[3]	CUM. LBS[4]
8/18/2003	66	47.8	0.04	336.93
9/2/2003	64	46	0.04	337.49
9/15/2003	64	47.5	0.04	337.95
10/1/2003	39	50.4	0.02	338.54
10/15/2003	39	16.2	0.01	338.87
11/3/2003	75	65.61	0.06	339.01
11/14/2003	75	65.82	0.06	339.66
12/1/2003	75	48	0.04	340.67
12/15/2003	75	45.7	0.04	341.28
1/2/2004	68	41	0.03	342.02

Notes:

NA indicates that data was not collected on this date.

[1] Flow values are estimated by dividing the total pumpage sums for each month by the number of minutes in that month.

[2] CCL4 concentrations are from analytical results.

[3] LBS/Day is calculated by multiplying the flow (GPM) * CCL4 concentration (PPB)* 0.0
(a conversion constant to arrive at pounds per day)

[4] Total mass of CCL4 removed since the start up of the system.

Density CCl4 = 13.1772 lb/gallon

Gallons removed = lb. Rem. CCl4 / Density C **25.37** gallons CCl4 removed

Note: Includes January 1999 removal action of 61.10 pounds